

Development of a USWRP Observing System Simulation Experiment (OSSE) test bed

Primary Objective (long term)

To establish a numerical test bed that would enable a hierarchy of experiments to:

- (1) determine the potential impact of proposed space-based, sub-orbital, and in situ observing systems on analyses and forecasts,
- (2) evaluate trade-offs in observing system design, and
- (3) assess proposed methodology for assimilating new observations in coordination with the Joint Center for Satellite Data Assimilation (JCSDA).

Sub-objectives

- (1) To define both the advantages and limitations of a hierarchy of OSSEs that includes rapid prototyping of instrument or data assimilation concepts, as well as the more rigorous “full” OSSEs.
- (2) To generate an OSSE/OSE process that invites participation by the broad community of agency planners, research scientists and operational centers.

FY09 Statement of Work

- We proposed to design an OSSE testbed for use by USWRP partners and academia as a collaboration between OAR/AOML, OAR/GSD, NESDIS/STAR, NWS/EMC and the Joint Center for Satellite Data Assimilation (JCSDA).
- This testbed would be applicable to analysis/forecast impact studies, observing system design, instrument trade studies, future instrument constellation planning, and data utility investigations.

FY 09 Tasks

- Task 1: Define the critical components of the OSSE testbed.
- Task 2: Identify and estimate resources (computational and human) required by the test bed.
- Task 3: Identify responsibilities for those agencies and institutions likely to be involved in the design, building and execution of experiments.
- Task 4: Identify a series of OSSEs that would serve as candidate experiments to be executed during the development of the test bed, and identify near-term (1-3 yr), mid-term (3-5 yr) and longer term (5-10 year) priorities.
- Task 5: Coordinate test bed plan between AOML, GSD, EMC, and NESDIS STAR, and then with the JCSDA.

Activity on SOW FY09

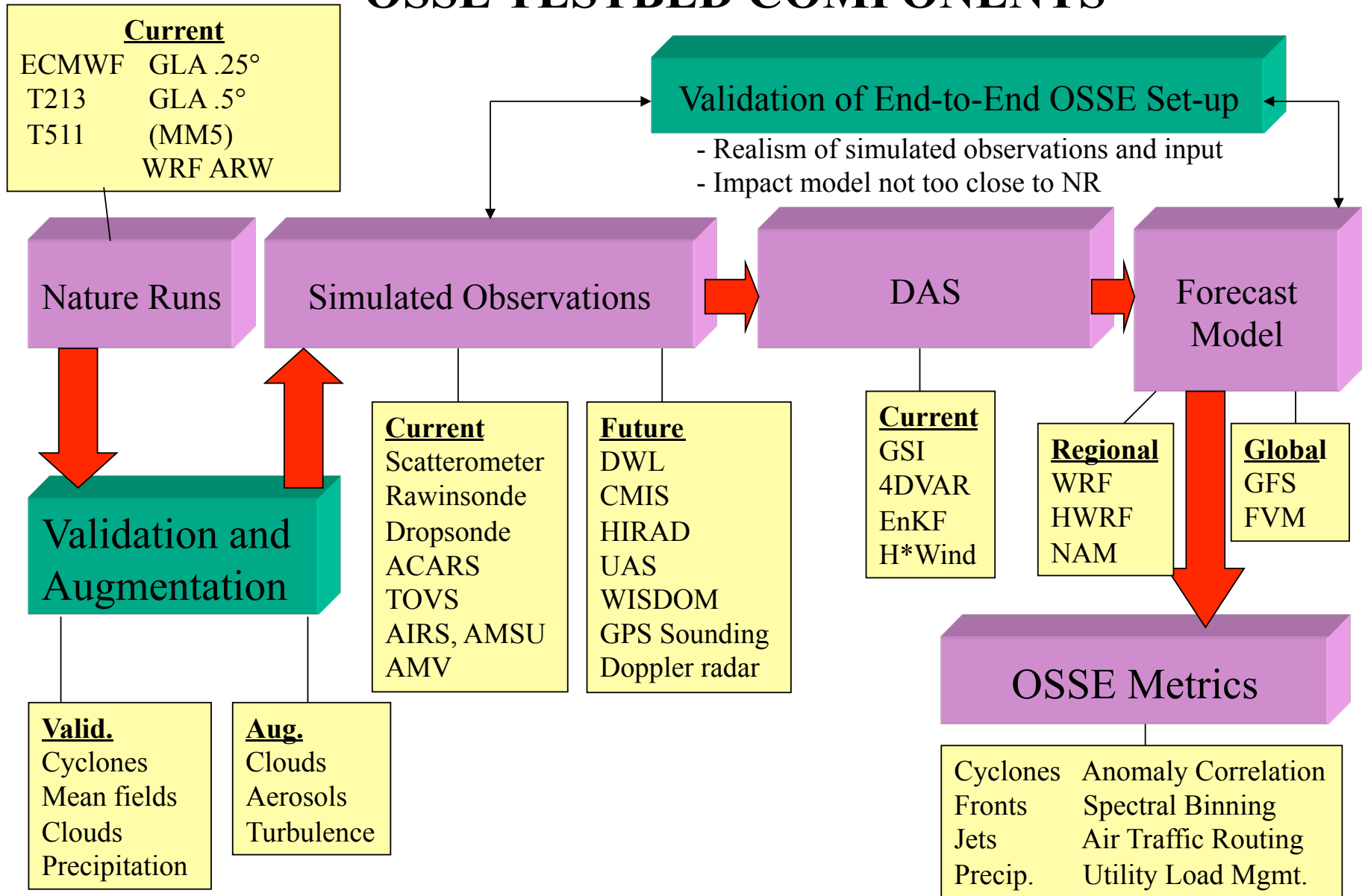
All FY 09 tasks were completed as follows:

- The critical components of an OSSE Testbed capable of supporting both global and regional OSSEs, and a hierarchical approach for conducting OSSEs were defined.
- Estimates of resources for OSSEs were developed and provided to EMP.
- A Terms of Reference (TOR) document for a USWRP OSSE Testbed was written and provided to all NOAA partners for comment and input. Where input was provided, it was incorporated into the TOR.
- Candidates for initial OSSEs were considered with the highest priority given to existing OSSE activities where partnering is possible. This includes OSSEs in support of the UAS program, HFIP, WISDOM balloons, wind lidar, surface winds (next scatterometer and HIRAD), and sensor web development.

De-scoped SOW for FY10

- In recognition of modest FY10 funding available for the seeding of a USWRP OSSE Testbed, we will focus on the continued development of an OSSE Testbed within NOAA in collaboration with NOAA and JCSDA partners, but will need to limit the applications and usage.
- In FY 10, this will involve:
 - providing expertise in finalizing the global OSSE system that has been under development for the last 5 years, and in conducting OSSEs with this system
 - developing a validated regional OSSE system
 - participate in conducting initial OSSEs for one or more of the candidate systems
 - work with USWRP, HFIP, EMP and others to broaden the base for funding the full testbed.

OSSE TESTBED COMPONENTS



Statement by Environmental Modeling Program Manager

“As discussed, the NOAA Environmental Modeling Program (EMP) believes that OSSEs and OSEs are essential tools for maximizing the impact of current and planned observational platforms on NOAA’s forecast and modeling products. The EMP has promoted the development of an NOAA-wide OSSE capability for several years and, thanks to the continued leadership shown by the USWRP, we are better able to articulate and prove the value and utility of these tools. The EMP looks forward to the further advancement of these activities with the development of an OSSE Testbed and hopes it will be included as a critical component of the overall environmental observation and prediction strategy for NOAA in the future.

- Alan

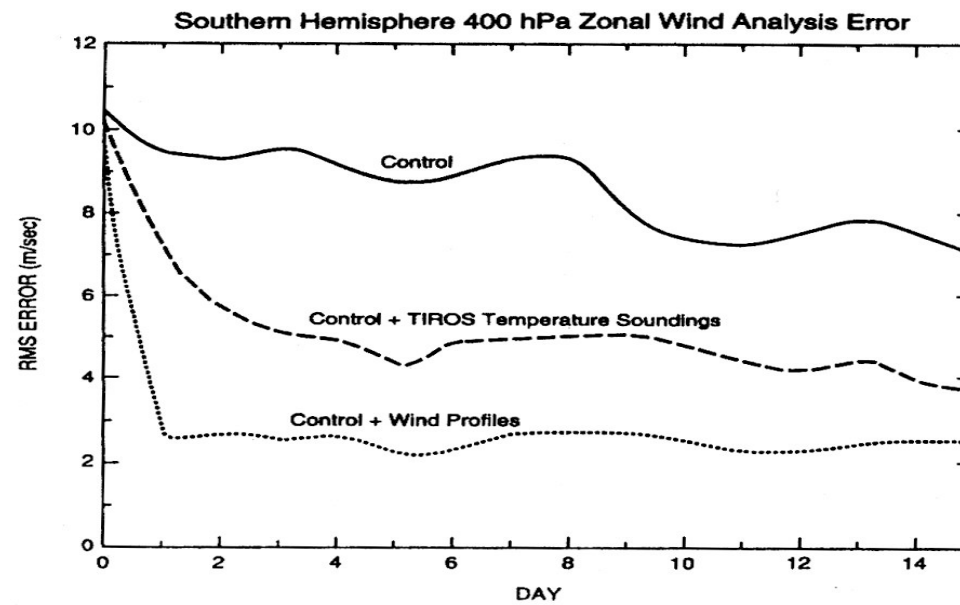
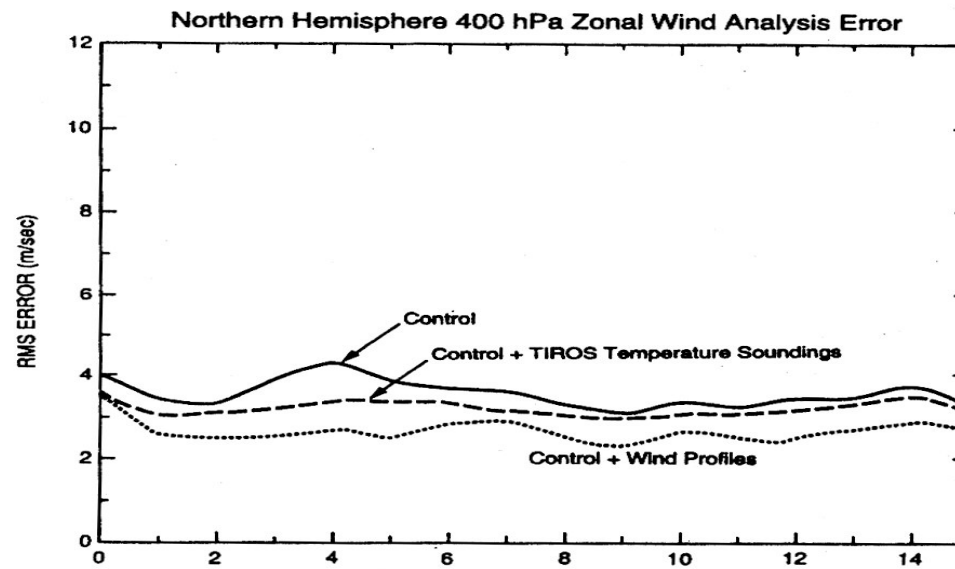
Backup slides

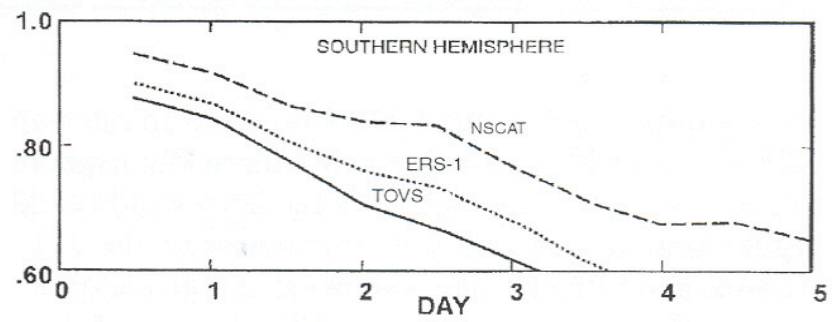
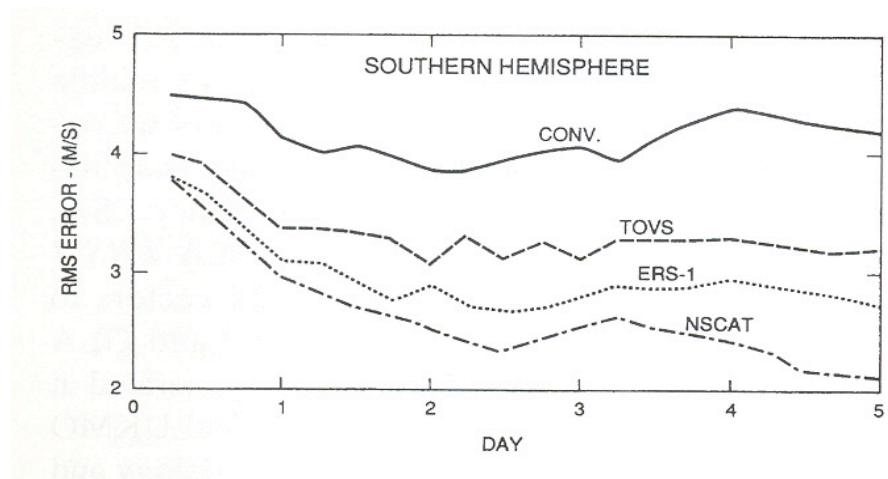
Previous OSSEs

1. **EVALUATED THE RELATIVE IMPACT OF TEMPERATURE, WIND AND MOISTURE DATA** - These experiments showed wind data to be more effective than mass data in correcting analysis errors and indicated significant potential for space-based wind profile data to improve weather prediction. The impact on average statistical scores for the northern hemisphere was modest, but in approximately 10% of the cases a significant improvement in the prediction of weather systems over the United States was observed.
2. **EVALUATED THE RELATIVE IMPORTANCE OF UPPER AND LOWER LEVEL WIND DATA.**- These experiments showed that the wind profile data from 500hpa and higher provided most of the impact on numerical forecasting.
3. **EVALUATED DIFFERENT ORBITAL CONFIGURATIONS AND THE EFFECT OF REDUCED POWER FOR A SPACE-BASED LASER WIND SOUNDER (LAWS).**- These experiments showed the quantitative reduction in impact that would result from proposed degradation of the LAWS instrument.
4. **DETERMINED DRAFT DATA REQUIREMENTS OF SPACE-BASED LIDAR WINDS.**-These experiments evaluated different coverages, resolutions, and accuracies for lidar wind measurements to estimate both research and operational requirements for the Global Tropospheric Wind Sounder (GTWS) Mission.

Previous OSSEs (continued)

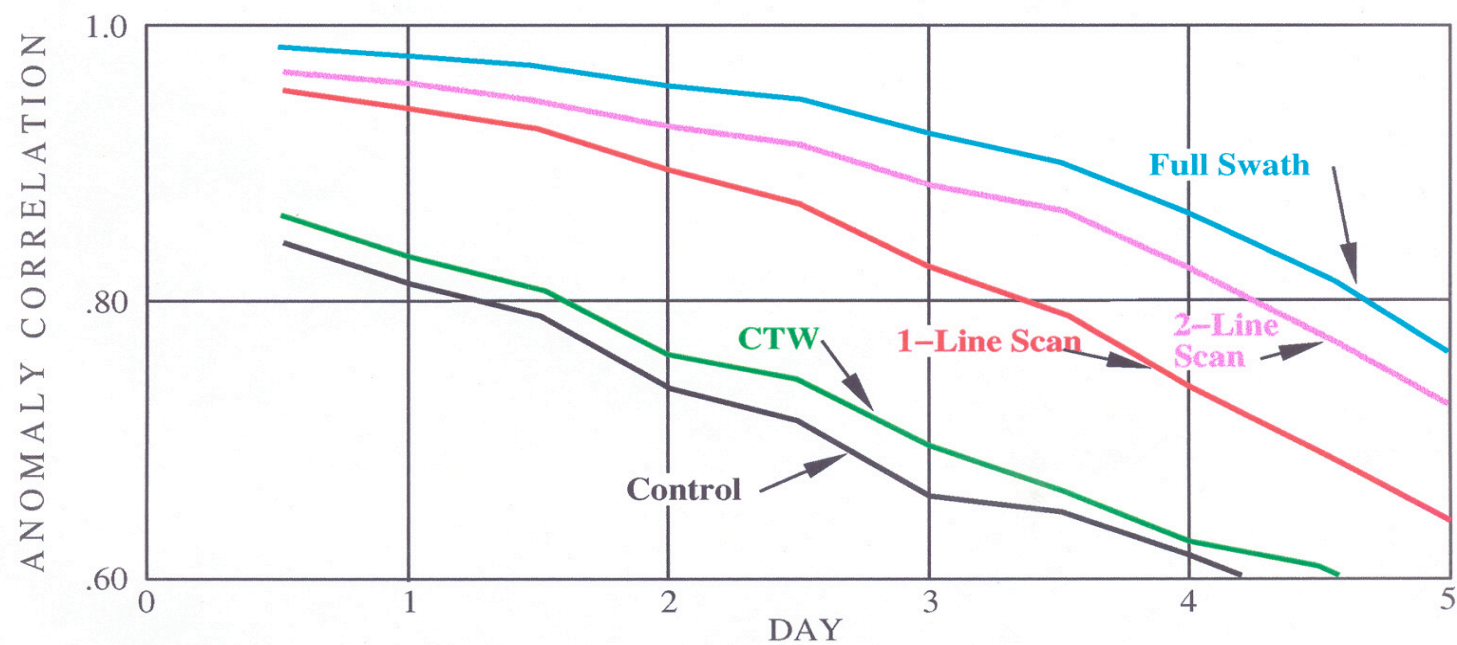
5. **DEVELOPED AND TESTED IMPROVED METHODOLOGY FOR ASSIMILATING SATELLITE SCATTEROMETER DATA.** - Applying this methodology resulted in the demonstration of the first significant positive impact of real scatterometer data in 1983.
6. **DEVELOPED AND TESTED DIFFERENT METHODS FOR ASSIMILATING SATELLITE SURFACE WIND SPEED DATA.**- This led to assimilation of SSM/I wind speed data to improve ocean surface wind analyses.
7. **EVALUATED THE QUANTITATIVE AND RELATIVE IMPACT OF ERS AND NSCAT YEARS PRIOR TO THEIR LAUNCH.**- These results were confirmed after the launch of both instruments.
8. **EVALUATED THE QUANTITATIVE IMPACT OF AIRS SOUNDING DATA AND THE IMPORTANCE OF CLOUD-CLEARING.** These results were also confirmed by later data impact experiments with real AIRS data.

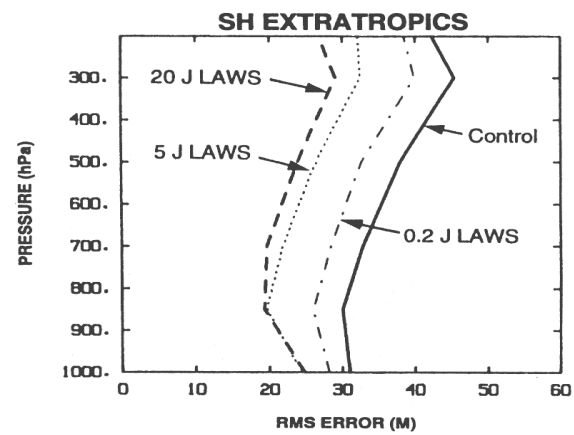
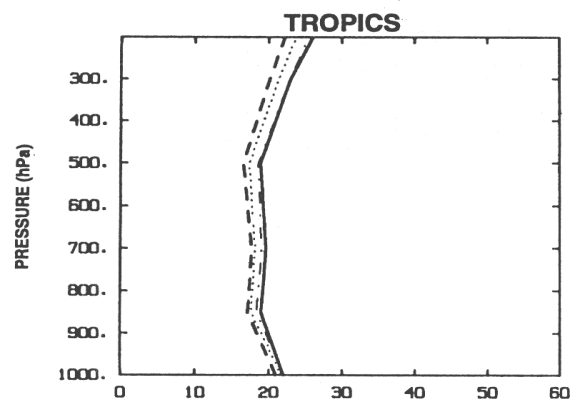
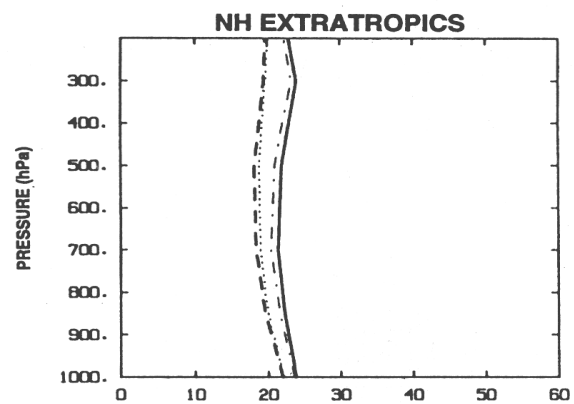




SEA LEVEL PRESSURE – S. HEM. EXTRA TROPICS

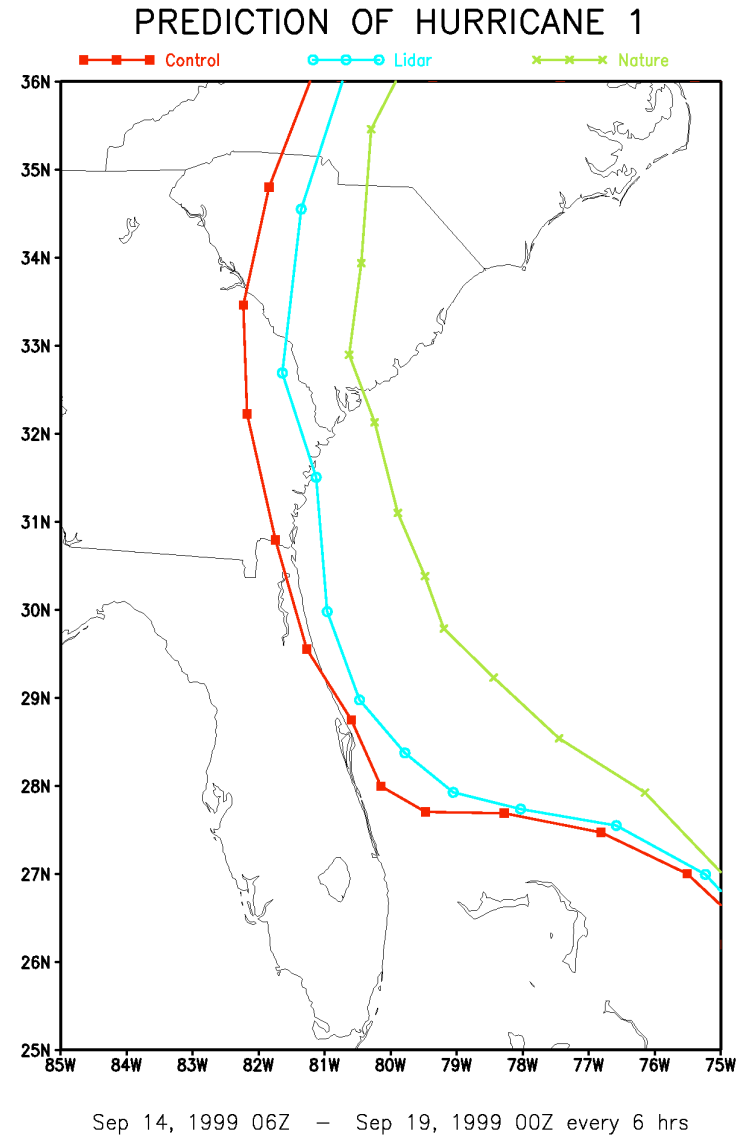
LAT : 86 S – 30 S LONG : 0 – 355 E



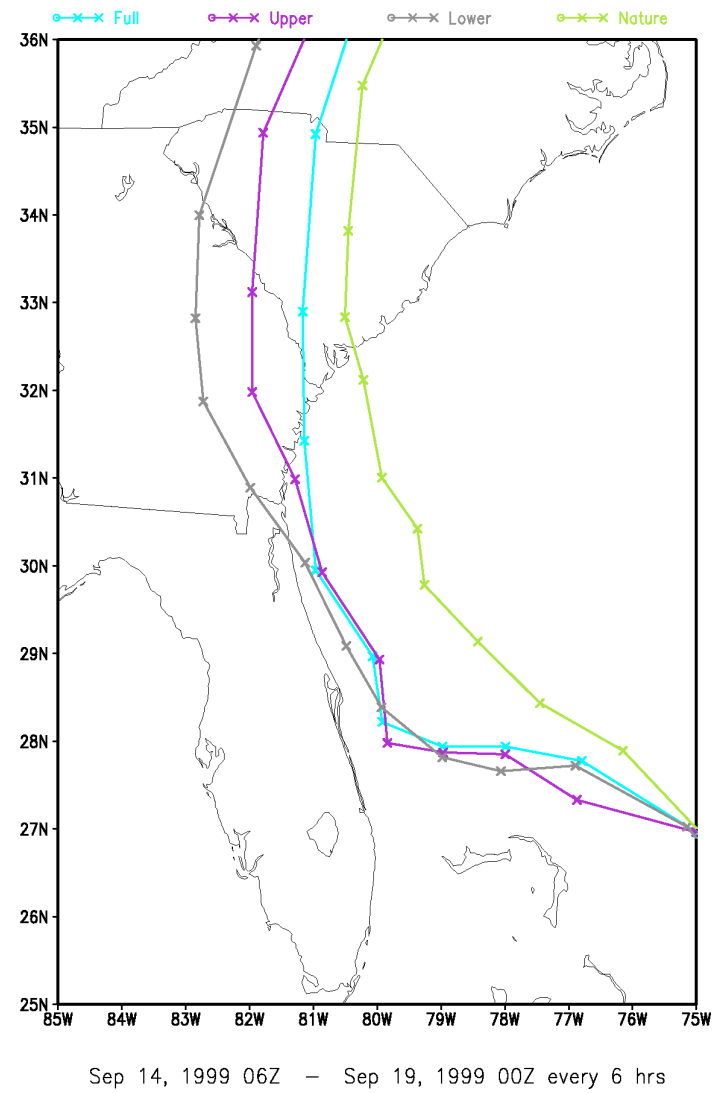


Potential Impact of new space-based observations on a Hurricane Track Prediction

- Tracks
 - Green: actual track
 - Red: forecast beginning 63 hours before landfall with current data
 - Blue: improved forecast for same time period with simulated wind lidar

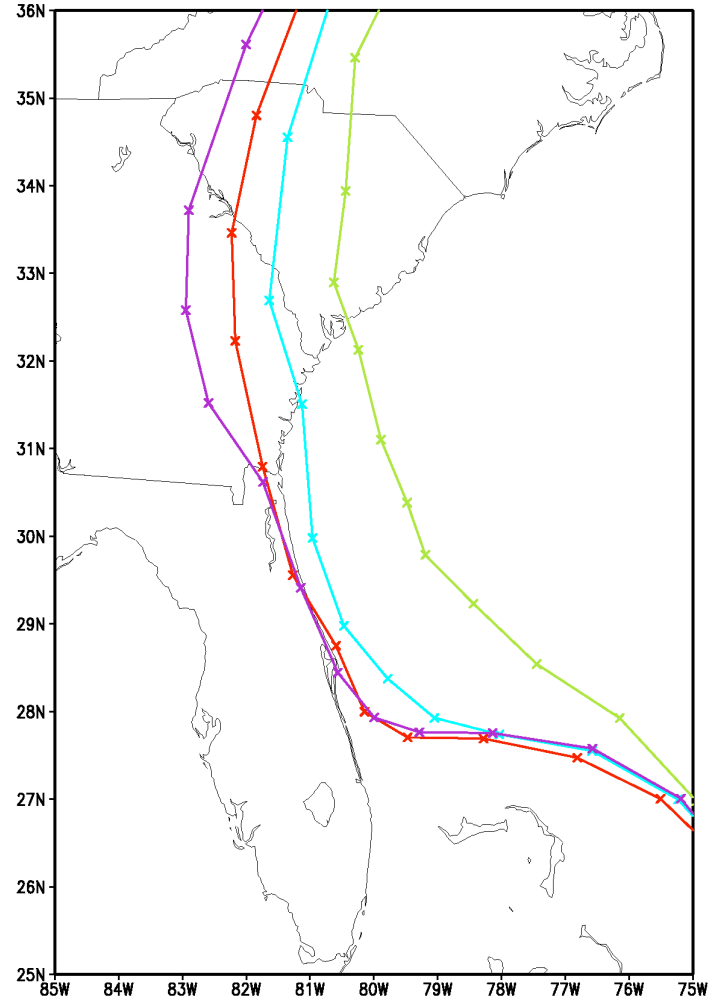


PREDICTION OF HURRICANE 1



PREDICTION OF HURRICANE 1

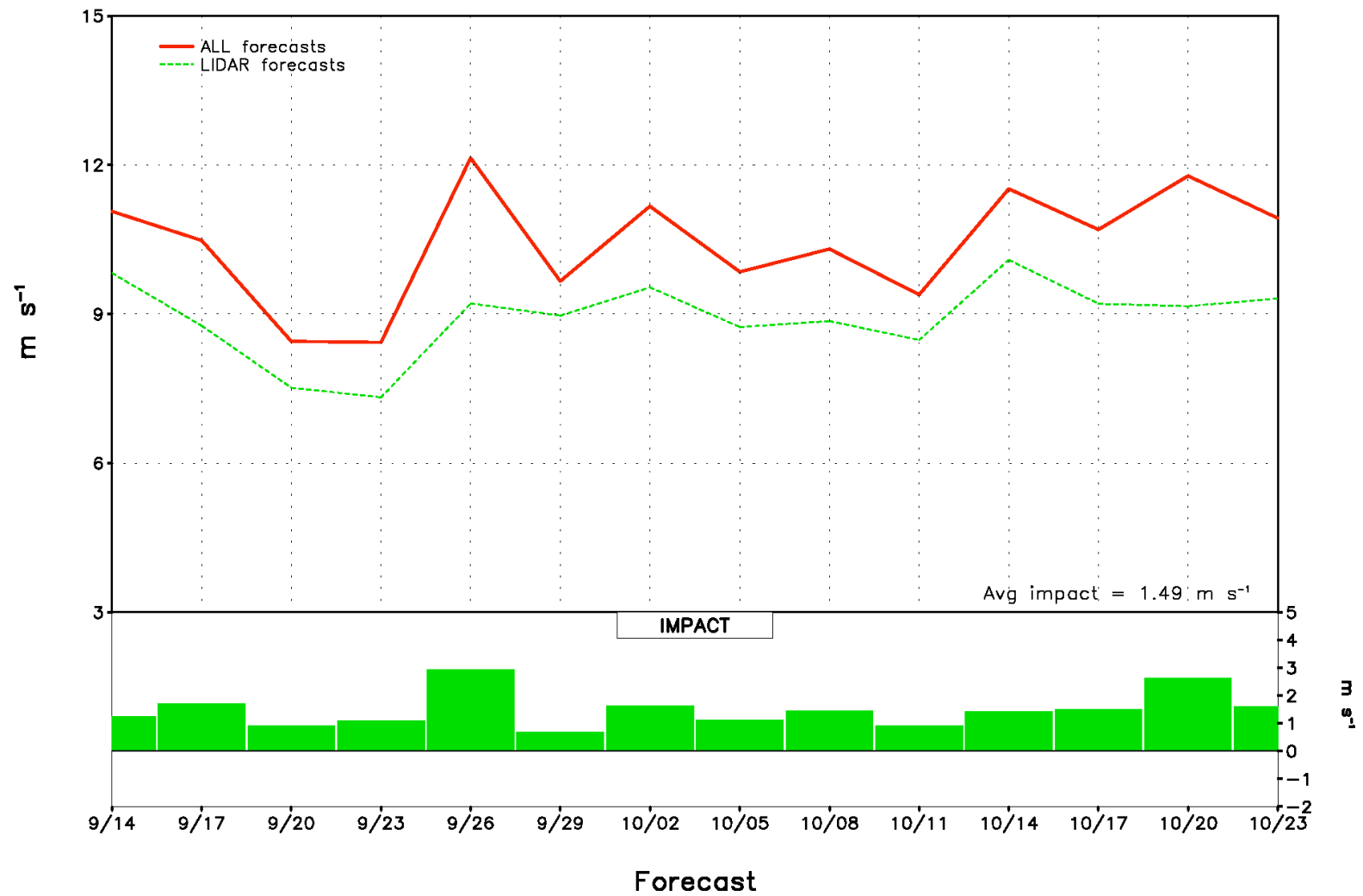
ALL FULL LIDAR NATURE NONSCAN LIDAR



Sep 14, 1999 06Z - Sep 19, 1999 00Z every 6 hrs

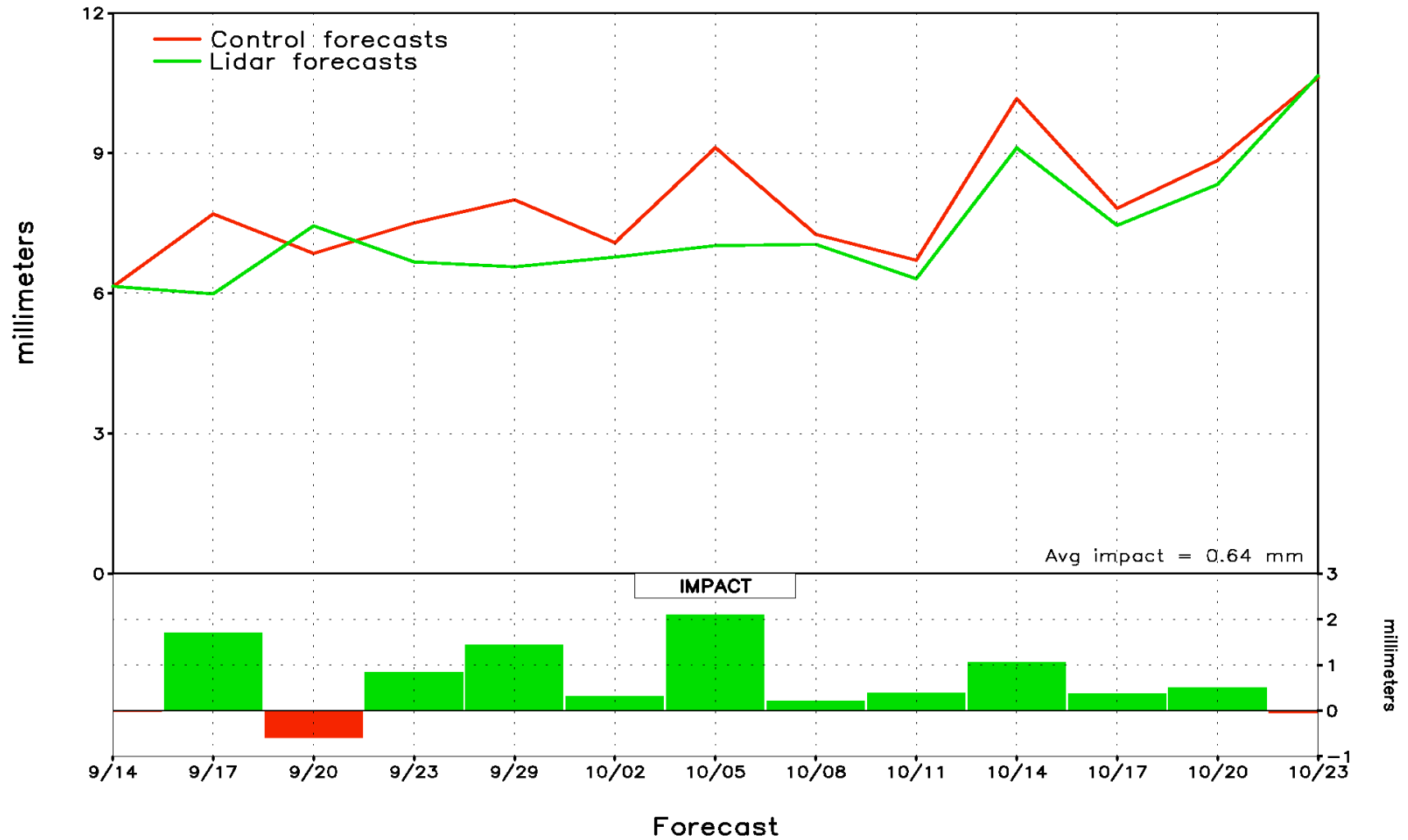
RMS Wind Speed Error at Nature Jet Streak Locations

24 Hour Forecasts



Precipitation Forecast RMS Error [Day 1]

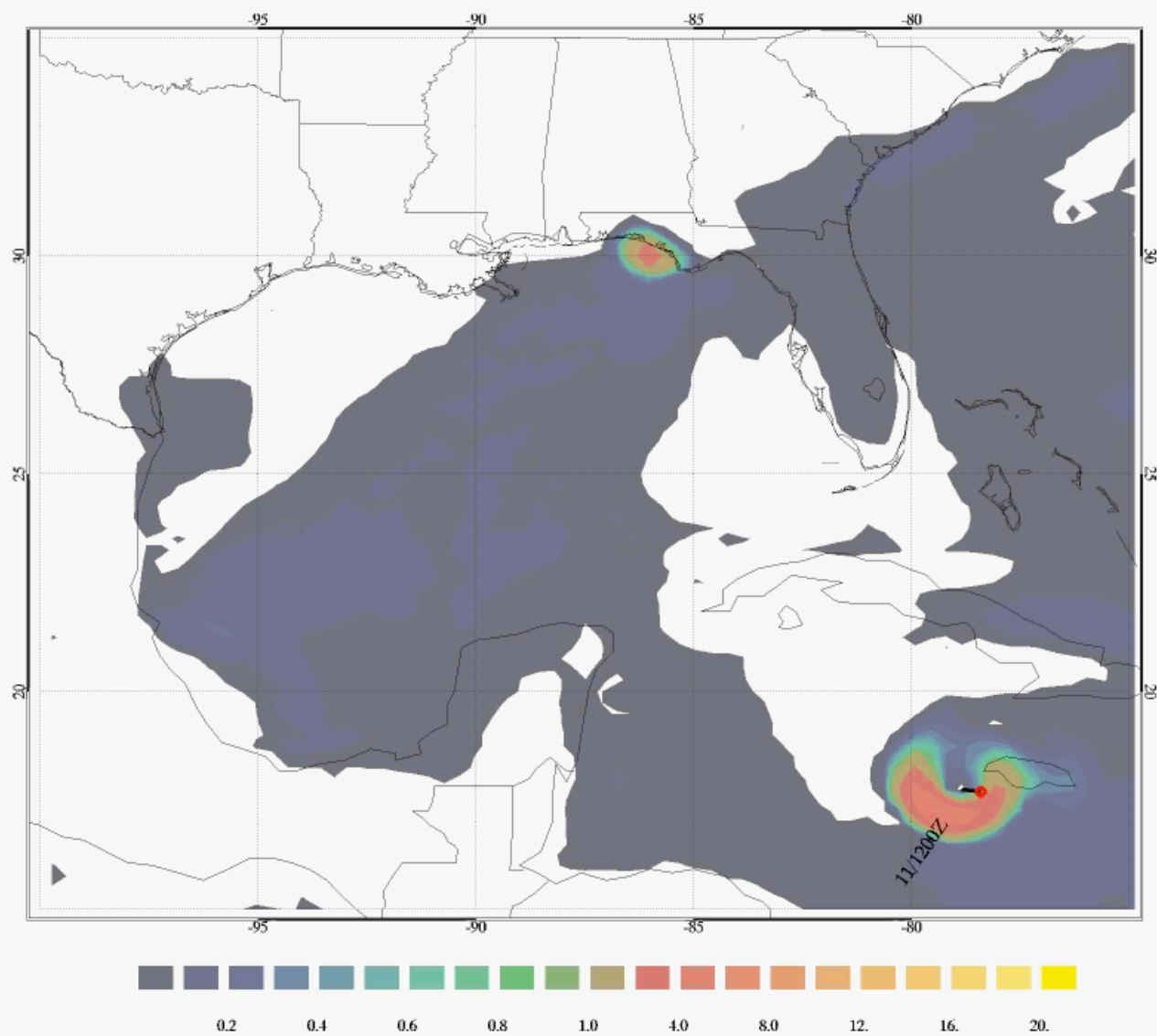
Global



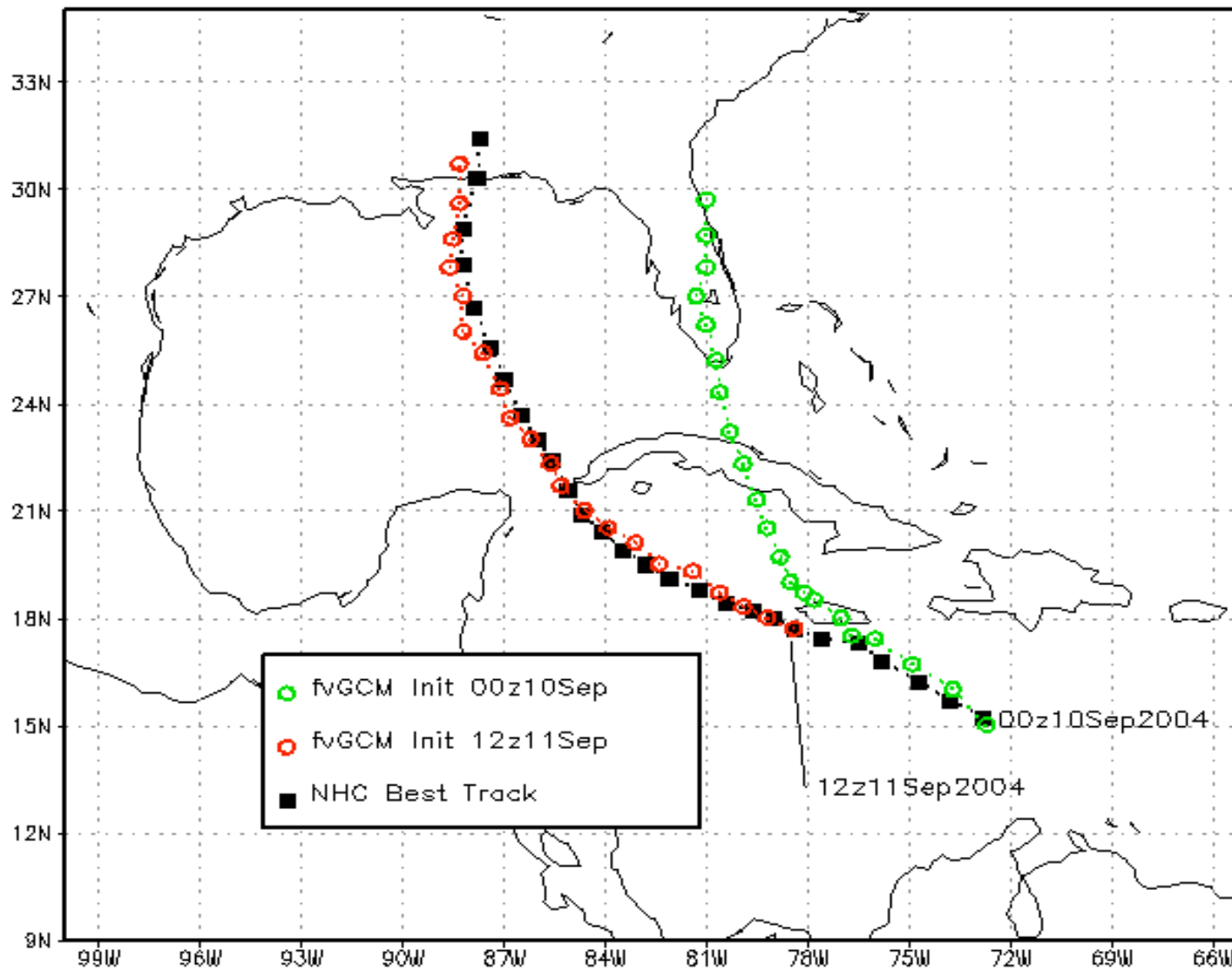
NASA fvGCM Hurricane Ivan Forecast Track [Black] and NHC Observed [Blue]

Accumulated Precipitation [inches]

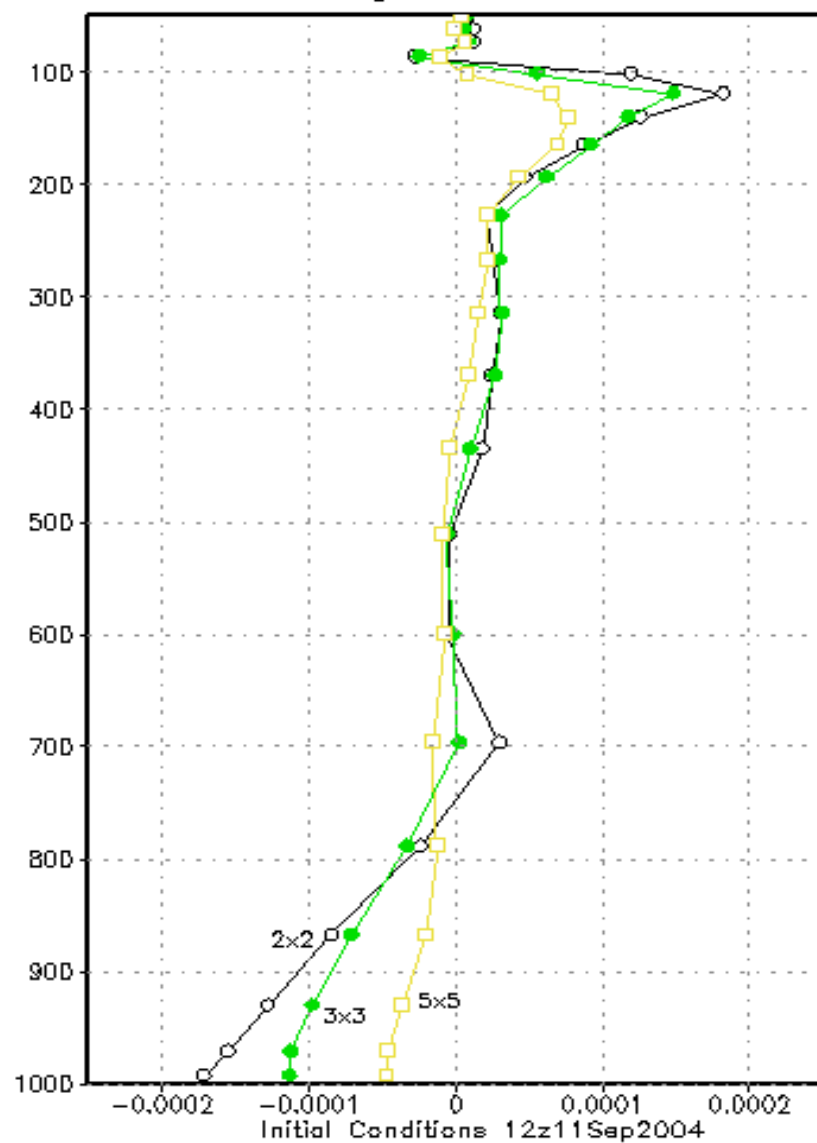
Initialized 2004 SEP 11 12Z : Valid 2004 SEP 11 15:00Z



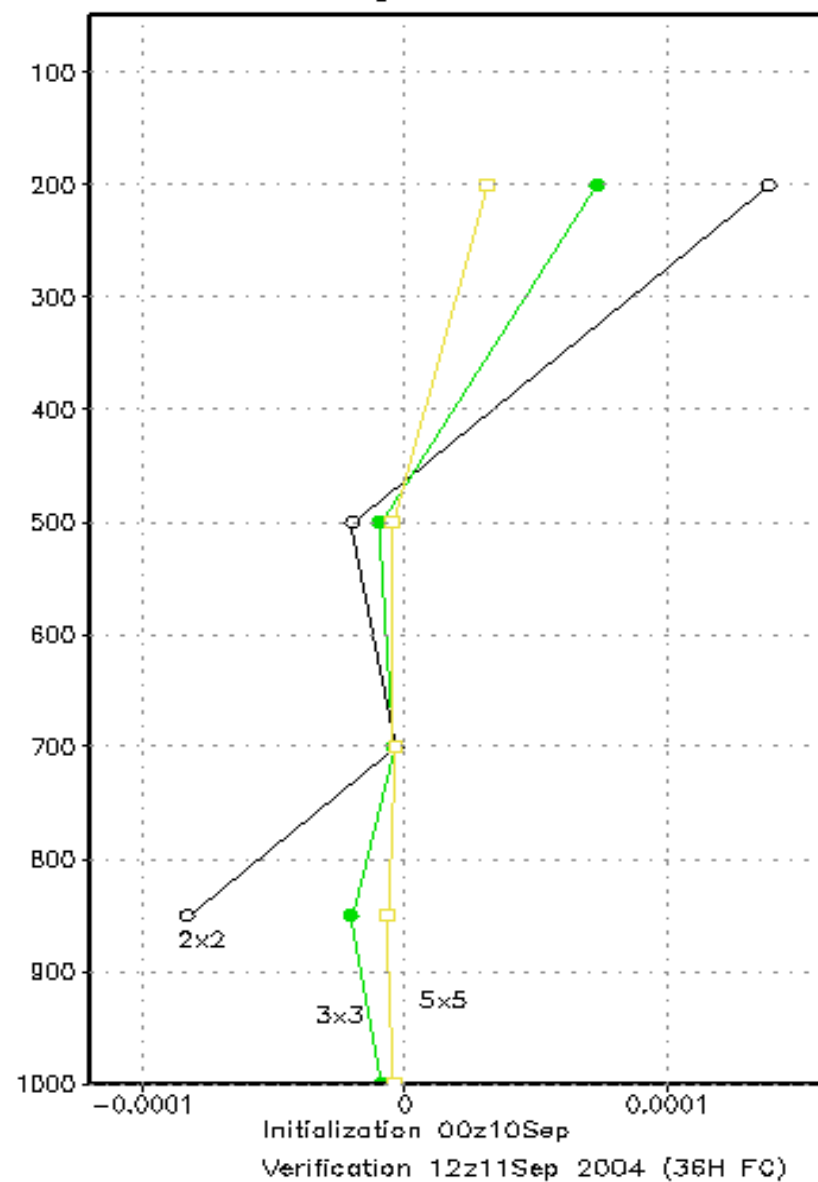
Hurricane Ivan



Area-avgd. Div. Profile



Area-avgd. Div. Profile



Description of Quick OSSE Experiments

Nature Run : fvGCM .25 x .36 deg horizontal resolution,
start on Sep. 11, 2004 at 12z

Observations : simulated from the Nature Run
for Sep. 11, 12z – Sep.12, 12z, 2004.

Data Assimilation Experiments : fvSSI , 1 x 1.25 deg resolution,
ran Sep. 11, 00z – Sep.12, 12z, 2004.

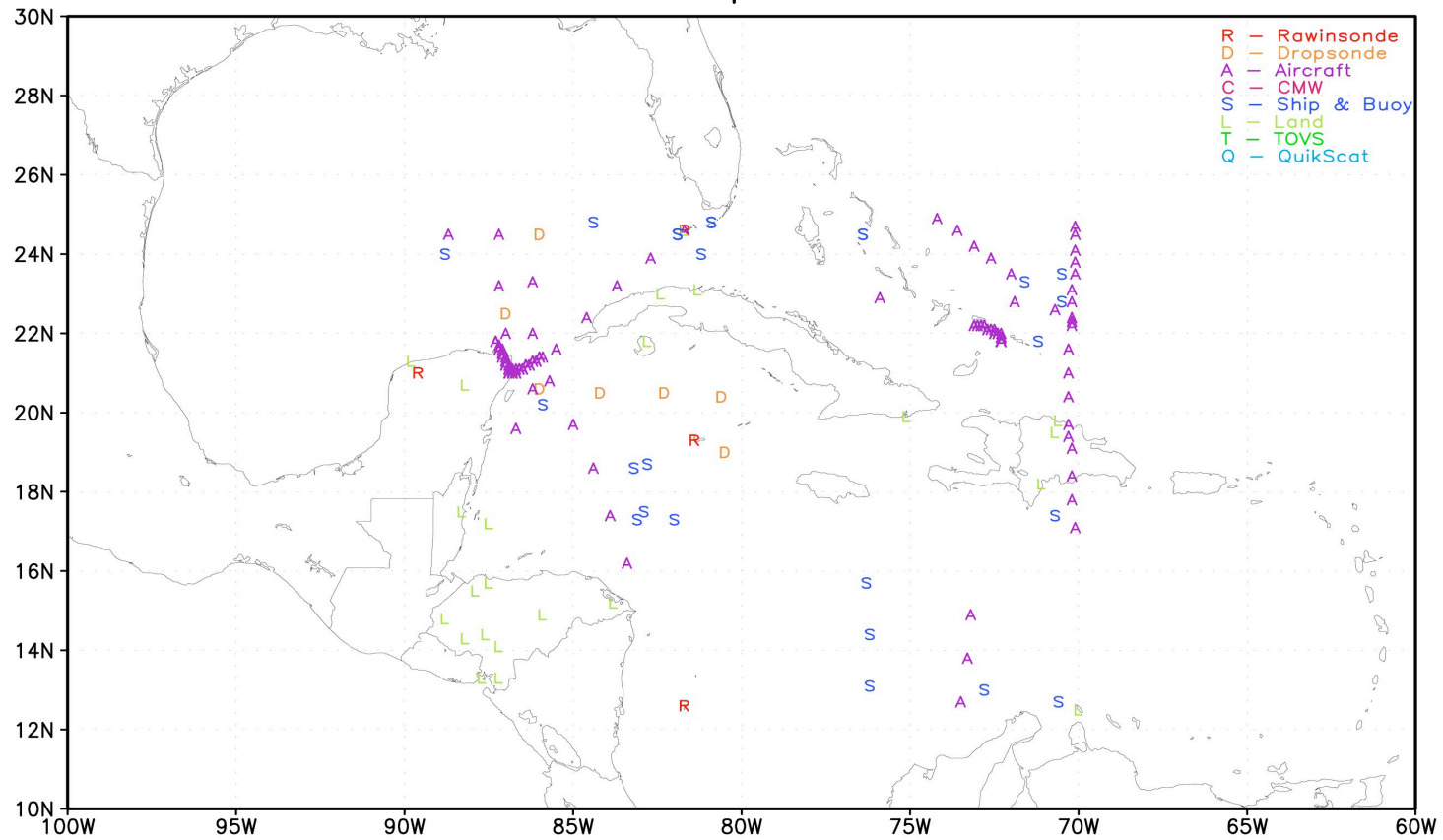
Control - compliment of operationally globally observed data,
including satellite temperature profiles

Lidar - Idealized wind profiles added in the vicinity of the hurricane

5 Day Forecasts : Started on Sep.11, 12z, Sep.12, 00z and 12z
ran at both 1 x 1.25 deg and .25 x .36 deg horizontal resolution

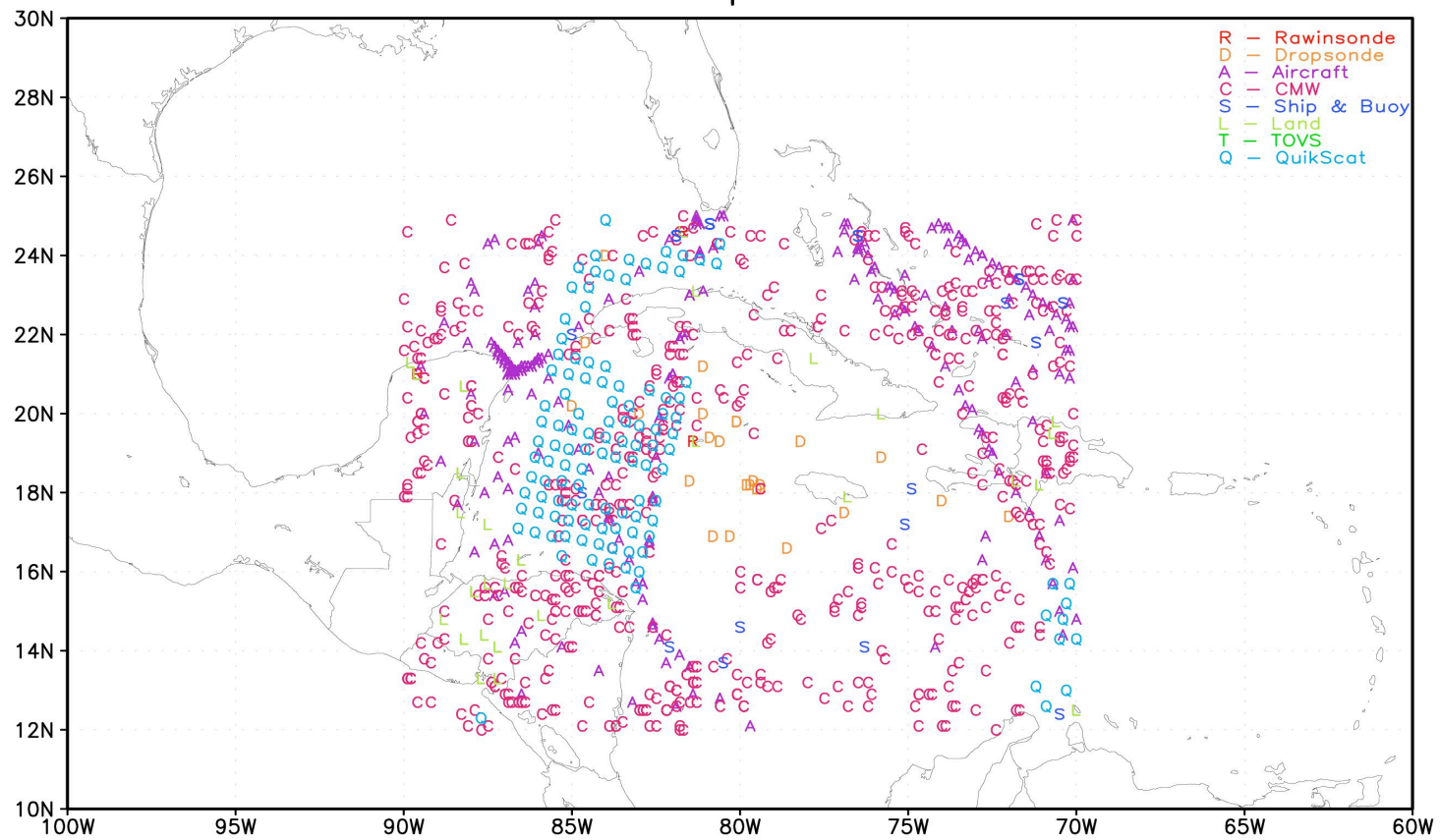
Observing System Wind Coverage for Quick OSSE

2004 Sep 11 12Z



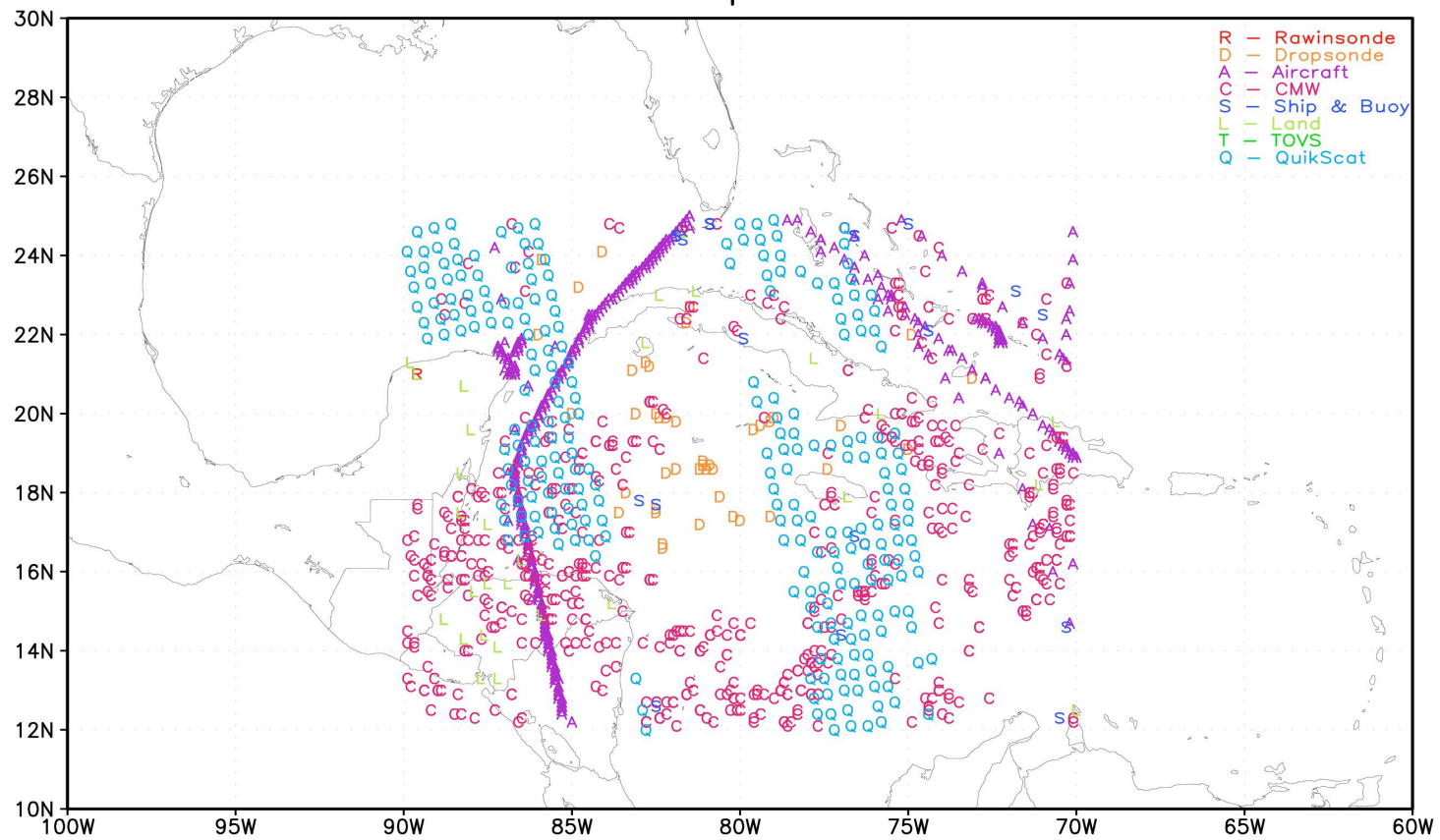
Observing System Wind Coverage for Quick OSSE

2004 Sep 12 00Z

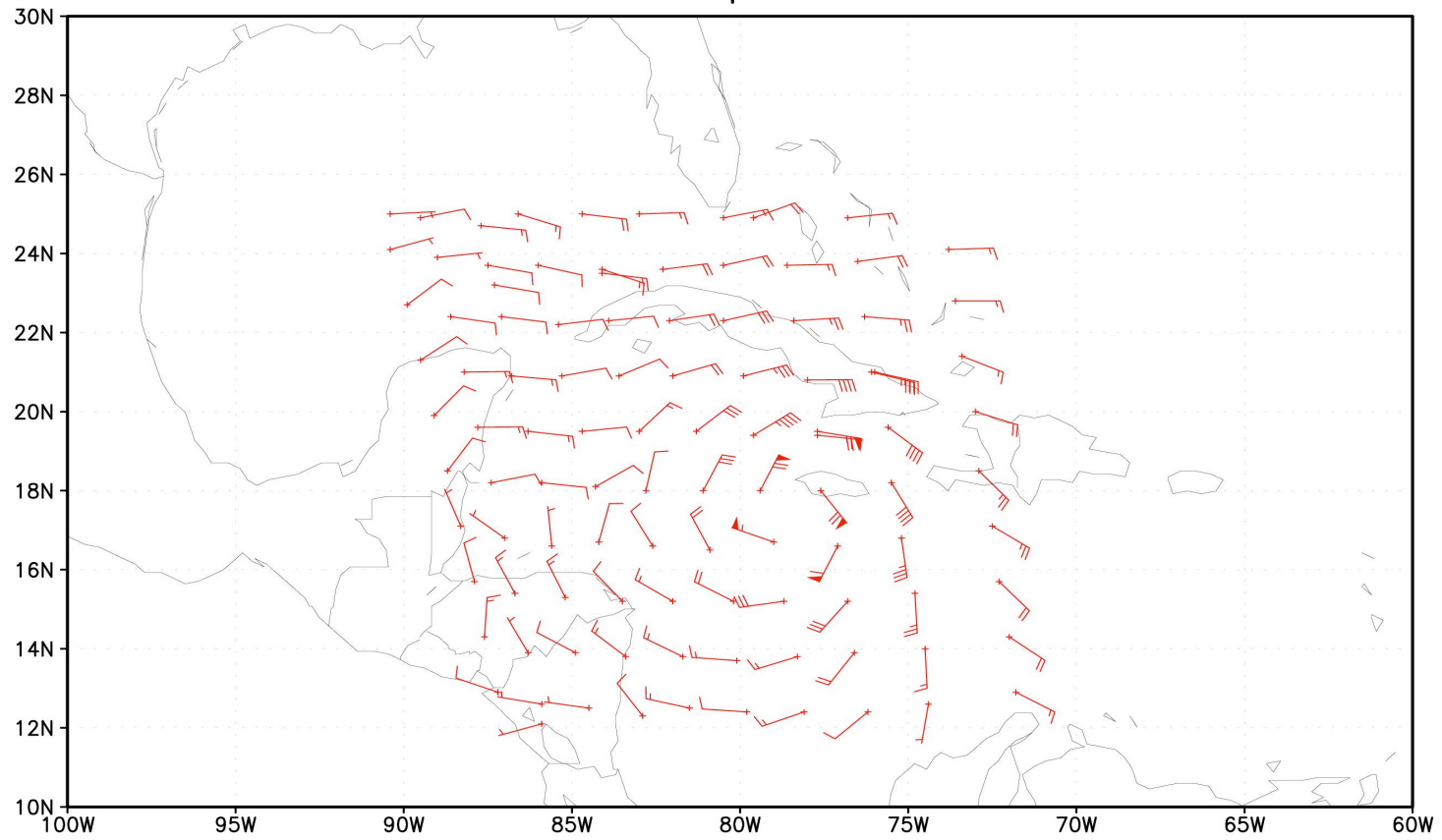


Observing System Wind Coverage for Quick OSSE

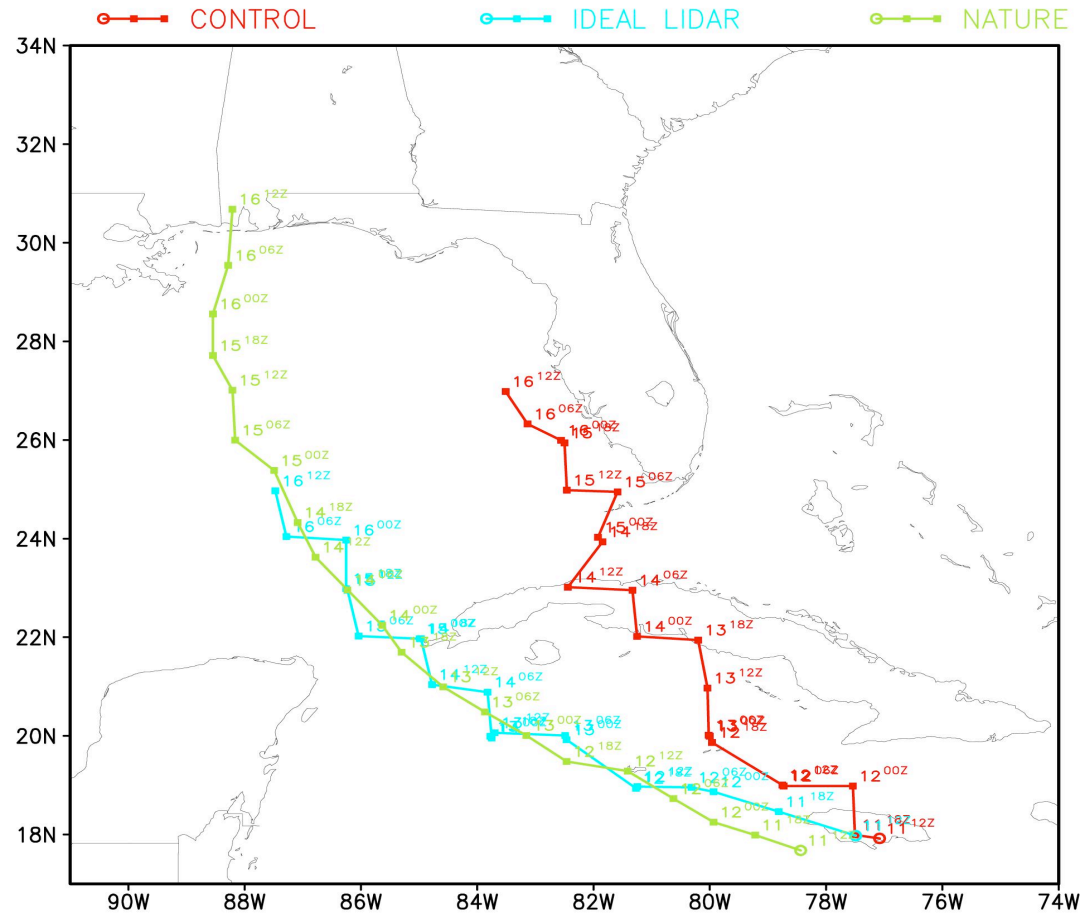
2004 Sep 12 12Z



Simulated 850 hPa Idealized Lidar Winds with Errors
2004 Sep 11 12Z



Prediction of Ivan (1° FvGCM Forecasts)



Sep 11, 2004 12Z – Sep 16, 2004 12Z every 6 hrs

Motivation for performing OSSEs

- Costs of developing, maintaining & using new space-based observing systems typically exceed \$100-500 M/instrument
- Significant time lags between instrument deployment and eventual operational NWP use
- Other than OSSEs there is no quantitative foundation for design & implementation of observing systems
- OSSEs can provide quantitative information on observing system impacts
 - New instruments
 - Alternative mix of current instruments
 - Data assimilation system diagnosis and improvement
- Information from OSSEs can lead to better planning and decisions

Basic Concepts

- In OSSEs
 - “*Nature Run*” is proxy for *Real Nature*
 - Free run of forecast model
 - Realistic phenomenology and variability vs. Nature
 - As independent as possible from Data Assimilation system model
 - Correlated biases introduce optimism
 - Construction of observations from Nature Run should also be independent
 - *Truth is known*
 - Verification vs truth can reveal characteristics of data assimilation system
 - *New observations can be simulated*

Basic Concepts (cont)

- *Simulated observations should be as realistic as possible*
 - Exhibit same system impact as real observations
 - Contain same kinds of errors as real observations (e.g. representativeness)
 - Nature Run is truncated spectrally in space & time
 - Real Nature is not truncated
 - Be produced by different instrument models than used in data assimilation system (e.g. radiances)
- For application to advanced observing systems
 - Data Assimilation system should be leading edge but well tested
 - OSSEs should be run periodically leading up to deployment of new instruments

OBSERVING SYSTEM SIMULATION EXPERIMENTS

OBJECTIVES:

1. To provide a **QUANTITATIVE** assessment of the potential impact of proposed observing systems on earth system science, data assimilation, and numerical weather prediction.
2. To evaluate new methodology for the processing and assimilation of remotely sensed data.
3. To evaluate tradeoffs in the design and configuration of proposed observing systems (e.g. coverage, resolution, accuracy and data redundancy).
4. Can also be used to determine the ability of existing observing system to detect climatic trends and to optimize the global observing system for climate monitoring and other applications.